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QUARTERLY PROGRESS REPORT

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Bellcomm, Inc.

Report No. 65-101-2
Contract NASw-417
May 31, 1965

NASA APOLLO PROGRESS REPORT

BELLCOMM, INC.

QUARTERLY PROGRESS REPORT

January February March

1965

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J. A. Hornbeck
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BELLCOMM, INC.

Washington, D. C.

Report No. 65-101-2
Contract NASw-417

QUARTERLY PROGRESS REPORT

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BELLCOMM, INC.

Report No. 65-101-2
Contract NASw-417

ABSTRACT

The activities of Bellcomm, Inc., during the quarter ending March 31, 1965, are summarized. Reference is made to reports and memoranda issued during this period covering particular technical studies.

BELLCOMM, INC.

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BELLCOMM, INC.

SPECIAL TASK STUDIES

The following is a summary of the status of effort either under way or completed during this quarter on Bellcomm's Special Task Orders under Contract NASw-417:

TASK ORDER NO. 1

ASSIST MSF IN THE PREPARATION OF DOCUMENTS DEFINING THE APOLLO MISSION AND SPECIFYING SYSTEM CHARACTERISTICS.

A draft of the Apollo Program Specification was completed and forwarded to MSF for review. This is to be the top level technical specification in the Apollo program and when approved will replace the Apollo System Specification M-DE 8000.001. The body of the specification covers the performance requirements on the operational version of the flight and ground equipment for the Saturn IB and Saturn V Missions. Appendices are being prepared to cover the planned flight-to-flight deviations.

A review of the December 14, 1964 draft of the Saturn V Project Specification was completed and informal comments were forwarded to MSFC.

The examination of Apollo interface control procedures initiated late in 1964 was continued during the first quarter of 1965. Effort focused on identification of inter-Center interfaces, examination of completeness of negotiations and documentation, and clarification of status information in the ICD log.

An assessment of Apollo interface control which included recommendations for immediate action to provide better visibility of inter-Center interface negotiation status was presented to MSF during the latter part of March.

TASK ORDER NO. 9

APOLLO TRAJECTORY ANALYSIS AND COORDINATION.

The guidance and navigation error analysis for the complete lunar landing mission is progressing on schedule. The production of powered flight sensitivity matrices, a preliminary step for the type of analysis being used, is essentially completed.⁽¹⁾ ⁽²⁾ A major part of the error analysis results will be forthcoming during the next quarter.

Work toward standardization of coordinate systems for Project Apollo has been proceeding during this quarter. Two inter-Center meetings⁽³⁾ ⁽⁴⁾ ⁽⁵⁾ have been held to review successively more refined drafts⁽⁶⁾ of a proposed OMSF directive defining the Project Apollo Coordinate System Standards.

Work has continued toward completion of a proposal for validating Apollo mission trajectories, and a report on this subject is in process.

A preliminary lunar accessibility study was completed.⁽⁷⁾ As a part of this study, maps were presented which show the areas of the moon which are accessible to Project Apollo for a variety of mission ground rules.

The performance capability of the Apollo Space Vehicle is being developed in terms of the accessible lunar landing area and the pattern of launch opportunities. During the next quarter work will proceed toward results for free return missions which will include a sampling of all possible earth-moon geometrics.

-
- (1) Lunar Orbit Rendezvous Reference Trajectory Data Package Sensitivity Matrices for Apollo Error Analysis, STL, 8408-6084-RC000 (U) February 15, 1965 (CONFIDENTIAL)
 - (2) Sensitivity Matrix Data for LEM Ascent to 50,000 Foot Orbit, Memorandum for File, I. Bogner, March 3, 1965 (CONFIDENTIAL)
 - (3) Minutes of the Second Apollo Interface Coordinate Systems Meeting, Memorandum for File, J. S. Dudek, J. O. Cappellari, R. L. Wagner, February 1, 1965.
 - (4) Draft - Project Apollo Coordinate System Standards (the Proposed Text of an MSF Directive), R. L. Wagner, J. O. Cappellari, J. S. Dudek, February 19, 1965
 - (5) Minutes of the Third Apollo Interface Coordinate System Standardization Meeting, Houston, Texas, March 4, 1965, Memorandum for File, J. O. Cappellari, J. S. Dudek, R. L. Wagner, March 17, 1965
 - (6) A Proposed Set of Coordinate Systems for Project Apollo, Memorandum for File, J. O. Cappellari, J. S. Dudek, January 13, 1965
 - (7) Lunar Landing Site Accessibility for July 1969, TR-65-209-3 V. S. Mummert, March 31, 1965

Work has been done in conjunction with MSC to revise the spacecraft ΔV budget. The major refinements have been in estimates of guidance allowance, performance margins and contingency allowances.

A report on a study to determine the requirements on the LEM Landing radar for use in monitoring the powered descent of the LEM was issued.⁽⁸⁾

Work has been proceeding toward a proposal for validating guidance equations for a lunar landing mission. Discussions have been held with MSC and MSFC on their guidance validation plans.

Bellcomm has continued to provide assistance to MSC in their task of providing technical direction for the IBM backup computer program.

(8) Monitoring Procedures and Landing Radar Requirements During Powered Descent Phase of the Lunar Excursion Module (U) TR-65-209-1, W. G. Hefron, January 22, 1965 (CONFIDENTIAL)

TASK ORDER NO. 11

TO CARRY OUT STUDIES LEADING TO THE EVALUATION OF THE NATURAL ENVIRONMENT FACTORS, AND ASSOCIATED EXPERIMENTAL PROGRAMS, IMPORTANT TO THE SUCCESSFUL PERFORMANCE OF THE MANNED SPACE FLIGHT PROGRAM

Review of data on the meteoroid environment was continued. A technical report extended previous reviews to encompass the smaller meteoroid sizes.⁽⁹⁾ The disagreement among various techniques of measuring these meteoroids may ultimately shed light on the nature of meteoric material. The analysis will be directly useful in the estimation of meteoroid erosion rates.

Published data on solar proton events are under review as part of a study of the overall uncertainties in the radiation environment and usefulness of various techniques of measurement.

In a review of Lunar Surface Models, our current knowledge of the lunar surface was outlined. Information from Ranger VII was included.⁽¹⁰⁾ Ranger VIII and IX photographs were obtained from the Jet Propulsion Laboratories and are under intensive study.

Studies of lunar soil mechanics have continued. The studies are focused particularly on the relation of the usually measured soil properties to the problems of rocket exhaust impingement and spacecraft landings.⁽¹¹⁾

Lunar radar studies included evaluation of various proposals for the extension of lunar radar observations which promise to 'map' the moon's small scale roughness (averaged over areas as small as 10-20 Km in diameter).

Progress was made on two major documents during the quarter. The Natural Environment and Physical Standards for the Apollo Program received its final technical and program coordination, and is scheduled for release in April, 1965. Work on Requirements for Data in Support of the Apollo Program - Issue IV, has been initiated. Preliminary technical consultations with MSC were held, and progress toward a first draft was made. The Requirements, Issue IV, in contrast to earlier issues, is planned to be a program control document, defining a program interface

(9) The Micrometeoroid Environment of Project Apollo TR-65-211-2, J. S. Dohnanyi, February 25, 1965

(10) Lunar Surface Models, Memorandum for File, R. F. Fudali February 15, 1965

(11) The Effect of Rocket Exhaust Gas Impingement on Various Surfaces, Memorandum for File, N. W. Hinners, February 15, 1965

among MSF, ART, and SSA, as well as stating required data. Issuance is tentatively scheduled for mid-1965.

Technical support was provided to MSF on the targeting of Ranger 8 and 9 to provide lunar surface information useful for the Apollo Program. In addition, a computer program was written to find the position of the Ranger photographs relative to the lunar coordinates of the moon.

The methods of converting Ranger photography to topographic data are under continued study as a forerunner to analysis of Lunar Orbiter photography. A computer program has been written to compute the statistics of slope and protuberance at LEM scale. The computation times have been analyzed to size the Lunar Orbiter problem. The program is ready for use when further Ranger data are available in appropriate form.

Measurements of slopes and protuberances likely to be encountered by the LEM made on a three-dimensional lunar model constructed by USGS-Astrogeology from RA-7 photographs have been reported.⁽¹²⁾

The Ranger configuration of the Space Flight Operations Facility (SFOF) at JPL was examined. Documentation on SFOF and the interfaces with the Deep Space Net were studied to examine the facility support role for future unmanned missions including Surveyor and Lunar Orbiter.

The first meeting of the NASA Working Group on Surveyor Landing Aids for Apollo was attended on February 25 and 26 at JPL. In support of the above, a study was initiated on the acquisition time of a marker on the lunar surface by a radar scan.

The study on the lunar descent portion of the Surveyor mission was continued. Primary emphasis has been placed on Surveyor trade-offs in connection with radar (RADVS), downward looking TV, and spacecraft propulsion in relation to the capability for landing in the eastern portion of the Apollo zone of interest.

A Bellcomm technical report⁽¹³⁾ was completed in response to a request from SSA for MSF input to mission planning. This report was sent to SSA by MSF on February 18, 1965.

During this quarter a report⁽¹⁴⁾ was completed and delivered to MSF which summarized work performed under Task 11 through January 31, 1965.

(12) Ranger VII Photo Analysis - Preliminary Measurements of Apollo Landing Hazards - TM-65-1012-2, C. J. Byrne, March 17, 1965.

(13) Lunar Orbiter Mission Planning, (U) TR-65-211-1, D. D. Lloyd and R. F. Fudali, January 25, 1965 (CONFIDENTIAL)

(14) Summary of Work Performed under Bellcomm/NASA Task 11 TR-65-211-3, B. T. Howard, D. B. James, G. T. Orrok, February 26, 1965

TASK ORDER NO. 12

ASSISTANCE IN CERTAIN COMPUTER OPERATIONS AND RELATED ACTIVITIES

During the period of January 1, 1965 through March 31, 1965 NASA use of the 7044 computer was 4.25 hours along with 2.13 hours of independent 7040 usage. The separate entry for 7040 usage reflects hours that were used outside of Bellcomm's Monitoring System (BCMSYS).

TASK ORDER NO. 14

OPERATIONAL PLANNING

A task summary report covering task activities from October 1, 1963 to December 31, 1964 was delivered in January. (15)

The tracking analysis effort in support of the Mission Operations Analysis was continued with the completion of a computer program for translunar and lunar tracking studies. A report covering the atmospheric effects on tracking measurements was issued. (16)

The analysis of operational documentation continued with the examination and preparation of comments on the Mission Directives for the SA-9 and SA-201 flights. The Apollo Program Operations Plan was reviewed and a memorandum of comment was issued. (17) Current activity is on the evaluation of the Operations Plan for Mission 201.

(15) Summary Report on Task 14 - Operational Planning, Memorandum for File, R. W. Sears, January 15, 1965

(16) Atmospheric Correlation Effects in Range Rate Tracking, Memorandum for File, G. H. Myers, Bell Telephone Laboratories, Inc, January 28, 1965

(17) Comments on Apollo Program Operations Plan, Memorandum for File, P. L. Havenstein, February 5, 1965

TASK ORDER NO. 15

FORMULATION OF SYSTEM REQUIREMENTS FOR, AND EVALUATION OF,
COMMUNICATION FACILITIES TO BE USED FOR APOLLO FLIGHT MISSIONS.

The Apollo communications system including problem areas was reviewed.⁽¹⁸⁾

Results of an investigation into the communication and tracking coverage by the Unified S-band (USB) stations during the launch phase of Apollo missions were presented in two memoranda.^{(19) (20)} These studies evaluated both the space vehicle visibility from the proposed USB stations and the performance margins of the communications channels. It was recommended that a USB station be provided at Grand Bahama Island (GBI) in addition to those already planned for Merrit Island Launch area (MILA), Bermuda, Antigua, and the Insertion ship. This addition will permit continuous coverage of the Saturn V Apollo spacecraft from lift-off through insertion into earth orbit provided the S-band omnidirectional antennas offer coverage to within 10° of the spacecraft roll axis.

Investigations were made of the communications and tracking coverage for Apollo development missions of alternative types, e.g. elliptical orbits.

The effects of atmospheric refraction on the coverage provided by earth-based communication and tracking stations were reported.⁽²¹⁾

Analysis of the performance of the Unified S-Band (USB) communication system has continued. A memorandum was issued that described a method for calculating communication margins for phase modulated, frequency multiplexed one-way links.⁽²²⁾ A design philosophy for choosing modulation indices to maximize the communication range is included. Similar memoranda are being prepared for the design of the ranging (two-way) modes of the USB system and the frequency modulation modes.

-
- (18) Review of Apollo Communication System - February 9, 1965, Memorandum for File, J. J. Hibbert, March 23, 1965
- (19) Apollo Saturn V Unified S-Band Communications and Tracking Coverage from Lift-Off through Insertion, Memorandum for File, J. P. Maloy, H. Pinckernell, March 19, 1965.
- (20) Unified S-Band Communications Margins During the Launch Phase of a Saturn V Apollo Mission, Memorandum for File, J. D. Hill, R. L. Selden, March 16, 1965.
- (21) Effects of Atmospheric Refraction on Coverage Provided by MSFN Earth Based Communications and Tracking Stations, TM 64-2021-1, H. Pinckernell, December 31, 1964.
- (22) Unified S-Band Communications Margins Calculations for One-Way Links, TM-65-2021-1, J. D. Hill, J. T. Raleigh, R. L. Selden, February 4, 1965.

The advantages and disadvantages of a USB communication system were reviewed. The present plans provide for VHF and X-band systems for the Apollo spacecraft in addition to USB. The need for those systems in addition to USB was studied. There appears to be no decided advantage of a totally integrated communications and tracking S band system over those systems using VHF and X band systems.

The investigation into the number of jet aircraft needed to provide communication coverage during the translunar injection phase of the Apollo lunar mission has been completed.⁽²³⁾ A memorandum was prepared which summarized the technical studies leading to the MSF decision to provide eight aircraft.⁽²⁴⁾ A memorandum was also issued on supporting studies on the injection aircraft.⁽²⁵⁾

The reliability to be expected of the communications in the Manned Space Flight Network (MSFN) for Apollo has been examined using past NASA network performance as a basis.⁽²⁶⁾ It is estimated that the average reliability of a single non-redundant channel used for voice or data transmission will be about 0.927 for a 24-hour interval (except for HF radio circuits which have a lower reliability). The estimated reliability is 0.999 that at least one of two redundant channels on independent, geographically diversified routes will be in operational condition at any time.

The investigation into the utility of communication satellites for the Apollo MSFN has continued. A summary memorandum will be issued shortly.

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- (23) Summary of Requirements for Instrumentation Aircraft During the Injection Phase of the Apollo Lunar Landing Mission, Memorandum for File, J. J. Hibbert, March 30, 1965.
- (24) Project Apollo - Further Studies of Aircraft Deployment to Provide Coverage During the Injection Phase, Memorandum for File, R. C. Peterson, J. M. Trecker, Bell Telephone Laboratories, Inc., December 10, 1964.
- (25) Project Apollo - Additional Results Concerning Aircraft Deployment to Provide Coverage During the Injection Phase, Memorandum for File, R. C. Peterson, Bell Telephone Laboratories, Inc., January 15, 1965.
- (26) Communication Reliability for the Apollo Manned Space Flight Network (MSFN) Based on Past NASA Network Performance, TM-65-2021-2, G. H. Speake, March 9, 1965.

TASK ORDER NO. 17

APOLLO FLIGHT MISSION ASSIGNMENTS STUDIES.

A revised issue of Apollo Flight Mission Assignments was approved and distributed in March, 1965.⁽²⁷⁾

Criteria were generated by which flight mission objectives will be classified as primary or secondary, and agreement for common use of these criteria was reached among appropriate MSF Directorates. Primary objectives have been drafted for all Saturn IB and Saturn V test flights. These objectives are being coordinated with the Centers. The Centers have agreed to use the primary objectives resulting from this coordination in the Master Test Plan and in Mission Directives.

Potential methods for increasing Saturn IB/Apollo payload capability by variations of flight profiles were assessed.⁽²⁸⁾ The methods include elliptical orbits, circularization following elliptical insertion, Hohmann transfer between circular orbits, and use of SM propulsion during the pre-insertion phase.

A memorandum was issued outlining current plans for conduct of the Saturn IB LEM development mission⁽²⁹⁾. Data were taken largely from planning documents generated at MSC and Grumman. The memorandum cites a need for further study to assure retention of stable platform alignment and to provide adequate tracking coverage.

A possible profile for a lunar mission simulation on vehicle 503 has been drafted.

-
- (27) Apollo Flight Mission Assignments (U), NPC-C500-11/SE 010-000-1, February 19, 1965 (CONFIDENTIAL)
- (28) Saturn IB/Apollo Payload Capability (U) Memorandum for File, H. S. London, February 2, 1965 (CONFIDENTIAL)
- (29) Saturn IB Test Mission for LEM Alone on SA-206, (U), Memorandum for File, D. R. Valley, February 1, 1965 (CONFIDENTIAL)

TASK ORDER NO. 18

PLANNING OF SYSTEMS OPERATIONS AND EXPLORATION TASKS - FIRST
PHASE MANNED LUNAR EXPLORATION.

Studies of post-Apollo missions in earth orbit, lunar orbit and on the lunar surface are continuing. The objectives and rationale of these missions are of particular interest as well as the technological requirements derived from the program objectives. Major effort has been devoted to a study of Apollo Extension System (AES) missions and, in particular, earth orbit missions. This work is progressing along three fronts:

1. Experiments for AES: Analysis of experiments suggested for the AES is continuing. Assistance has been provided MSF in monitoring studies of experiment/spacecraft integration being carried out by Apollo contractors through MSC.
2. Systems for AES: The capability of the Apollo system to carry out extended missions is under study. Modifications to Apollo systems such as spacecraft and ground support equipment are being studied in conjunction with MSF, MSC, MSFC, KSC and Apollo contractors. Drafts of several sections of the MSF document Apollo Technical Description for Earth Orbit dated March 1965 were supplied.
3. Program Analysis for AES: Analyses of scheduling problems, ground rules, contingency plans, launch vehicle and spacecraft allocations and program models are under way.

Preliminary results of AES studies directed toward the development of an AES Flight Mission Assignment Plan were published.⁽³⁰⁾

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- (30) Interim Report for AES Flight Mission Assignment Plan: Part I-Summary (U) TM-65-1011-7, T. L. Powers, January 29, 1965 (CONFIDENTIAL)
- Part II-Propulsion and Trajectory Capabilities, TM-65-1011-1, P. W. Conrad, R. Y. Pei, January 29, 1965
- Part III-Extended CSM Spacecraft (U) TM-65-1011-2, K. E. Martersteck, January 29, 1965 (CONFIDENTIAL)
- Part IV-LEM Objectives (U) TM-65-1011-3, J. E. Waldo, January 29, 1965 (CONFIDENTIAL)
- Part V-Lunar Mission Objectives and Rationale, TM-65-1011-4 N. W. Hinnners, January 29, 1965
- Part VI-Earth Orbital Mission Objectives and Rationale, TM-65-1011-5, W. B. Thompson, January 29, 1965
- Part VII-Scheduling Constraints and Alternative Schedules (U) TM-65-1011-6, P. Gunther, January 29, 1965 (CONFIDENTIAL)
- Part VIII-Launch Facilities and Equipment (U) TM-65-1033-1 V. Muller, H. E. Stephens, January 29, 1965 (CONFIDENTIAL)

High priority is being given to studies concerning NASA/AES -- DOD/MOL plans for earth orbit programs in terms of experiments, systems, missions, and program models.

Trajectory studies are progressing to investigate means of obtaining increased capability for AES lunar missions.

Effort has continued to develop a computer program to evaluate the motion and forces involved in a Ranger-derived hard-landing capsule system. The program has been completed, and as a result of inquiries from Langley Research Center and the Jet Propulsion Laboratory, the program is being formally written up so that copies may be sent to these Centers.

A technical memorandum on impact attenuation for lunar and planetary vehicles was completed.⁽³¹⁾

(31) Impact Response Characteristics and Associated Impact Attenuation Techniques for Lunar and Planetary Landing Vehicles, TM-65-1012-1, R. K. McFarland, January 21, 1965.

TASK ORDER NO. 19

ENGINEERING REVIEW OF ACCEPTANCE PLANS FOR THE MANNED SPACE-
FLIGHT CONTROL CENTER, LAUNCH DATA SYSTEM AND LAUNCH TRAJECTORY
DATA SYSTEM.

General sections of the Phase V Test Procedure Manual for SCATS readiness and the preliminary draft of the Phase V Single Vehicle Test Plan - Operational MSCC were reviewed. Detailed comments were provided to MSC. The principal effort during this quarter has been on the evaluation of the operational Phase V test procedures. Eight of these procedures have been reviewed and comments discussed with MSC personnel during working sessions.

Special studies continued in the analysis of the Communications Processor (CP) transfer and storage functions and in the preliminary design of quantitative tests for cathode ray tube display readability. The CP transfer function study has been completed. The study on readability continued during this quarter and plans were prepared which will permit laboratory verification of the procedures and test methods. (32) (33) (34)

Monthly Progress Letters^{(35) (36) (37)} summarizing the work accomplished under this task have been distributed.

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- (32) A Review of the Readability Potential of the Mission Control Center TV Displays, Memorandum for File, R. O. Wise, Bell Telephone Laboratories, Inc., February 3, 1965
- (33) Mission Control Center (MCC) Display Readability Experiments, Memorandum for File, S. J. Schoen February 27, 1965
- (34) Laboratory Test Methods for Determining Readability of TV Displays, Memorandum for File, R. O. Wise, Bell Telephone Laboratories, Inc., March 22, 1965
- (35) Monthly Progress Report for December, 1964, Letter to C. C. Kraft and W. E. Miller from P. L. Havenstein, January 15, 1965
- (36) Monthly Progress Report for January, 1965, Letter to C. C. Kraft and W. E. Miller from P. L. Havenstein, February 5, 1965
- (37) Monthly Progress Report for February, 1965, Letter to C. C. Kraft and W. E. Miller from P. L. Havenstein, March 10, 1965

TASK ORDER NO. 20

LUNAR LANDING SYSTEMS ENGINEERING STUDY

The primary objective of this study is to review and, if necessary, refine the functional specification of the LEM landing system. This involves the evaluation of the performance expected from LEM sub-systems effecting conditions immediately before and after touchdown. As part of this task, Bendix has been engaged, on sub-contract, in experimental work leading to the development of computer programs adequate to the description of LEM landing dynamics on different types of surfaces.

Since the Bellcomm effort on this task involves the analysis of these experimental data and use of the resulting computer programs, work during the first quarter of 1965 has been primarily accomplished at Bendix. Landing pad force data have been gathered and dynamic model drops have been accomplished on several soil surfaces. Initial attempts at computer simulation of these experimental data have been moderately successful. In addition, a new cantilever drop test model and multiple degree of freedom drop test rig are being developed. Interim reports have been distributed and discussions held with MSC, LRC, and MSFC personnel on Task 20 related subjects. (38) (39)

(38) Interim Report on Lunar Landing Systems Engineering Study, Bellcomm TR-65-220-1, D. Macchia, J. Nutant, March 10, 1965.

(39) Interim Report on Lunar Landing Dynamics Specific Engineering Studies, MM-65-2 Bendix Products, February 17, 1965.

TASK ORDER NO. 21

STUDIES CONNECTED WITH SATURN IB/V LAUNCH VEHICLE COMPUTER-
CONTROLLED ESE SYSTEM

A detailed review was performed of the Saturn IB/V data link terminals and modems (modulator - demodulator) acceptance test procedures. Specific recommendations were made for improving the confidence in the test results. These recommendations were incorporated into the acceptance tests procedures which were then approved at a joint meeting between MSFC, the contractor, RCA, and Bellcomm. A report covering the acceptance tests is in preparation. The discussion of acceptance tests identified an unsolved problem, i.e., a satisfactory method of measuring the undetected error rate. A method was subsequently developed for estimating this parameter⁽⁴⁰⁾.

(40) Procedure for Estimating Undetected Error Rate for the RCA Data Transmission System, TM-65-1031-1, J. S. Engel, March 9, 1965

TASK ORDER NO. 22

MANAGEMENT PROCEDURES IN COMPUTER PROGRAMMING FOR APOLLO

Since January, schedules and milestones for computer programming in Apollo are being reported regularly through the NASA reporting system (SARP). At present 39 software systems report each month on a single milestone: "software system acceptance." Three additional milestones will be reported for each system, starting in April. Bellcomm will continue to assist MSF in monitoring software schedules. Since January, two charts summarizing the status of Apollo software are prepared monthly for the Apollo Program Director.

A technical report dealing with techniques for monitoring the developmental progress of computer software, using SA-201 as an example, was completed and reviewed by MSF.⁽⁴¹⁾

In March, the section of a procurement plan dealing with computer programming prepared by the MSC Flight Crew Support Division was reviewed at the request of MSF.⁽⁴²⁾

Procedures covering certain areas of software management have been developed and incorporated in four coordination documents intended to be issued as official NASA documents.^{(43) (44) (45) (46)} Two of these reports have been reviewed by MSF, and revisions are currently being made before final issue in the next quarter.

-
- (41) Status and Schedule Monitoring of Apollo Software, TR-65-222-1, W. M. Keese, Et al, March 21, 1965
 - (42) Review of Procurement Plan for Programming Services, MSC Flight Crew Support Division Simulator Complex, I. D. Nehama, March 3, 1965
 - (43) Draft - Configuration Management of Computer Programming for Apollo, February 3, 1965
 - (44) Draft - Report Management of Computer Programming for Apollo, February 3, 1965
 - (45) Draft - Test Management of Computer Programming for Apollo - February 3, 1965
 - (46) Draft - Guidelines for Preparation of Technical Work Statements in Computer Programming in Apollo, April 7, 1965

TASK ORDER NO. 24

MILA OPERATIONS AND EQUIPMENT REVIEW

A study was undertaken to determine Saturn V/Apollo hold capability, recycle requirements and the principal constraints involved in the 72 hour time period preceding a launch attempt. The objectives of the study are outlined in a Memorandum for File.⁽⁴⁷⁾

A plan for reviewing the activation of Complex 39 and defining meaningful milestones for SARP chart reporting on the activation activities to MSF has been formulated and agreed to by cognizant MSF personnel. This review work has been started.

(47) Saturn V/Apollo Hold and Recycle Capability, Memorandum for File, C.
Bidgood, March 4, 1965

GENERAL MISSIONS STUDIES

BELLCOMM PERFORMS STUDIES, TECHNICAL FACT FINDING AND EVALUATION, ANALYTICAL INVESTIGATIONS, CONSULTING EFFORT AND RELATED PROFESSIONAL ACTIVITIES IN SUPPORT OF MANNED SPACE FLIGHT AND RELATED PROGRAMS OF NASA. THESE ARE CARRIED OUT AT BELLCOMM'S INITIATIVE OR MAY BE PRELIMINARY TO ISSUANCE OF SPECIAL TASK ORDERS.

- A. Small performance variations in the various Apollo Launch Vehicle propulsion systems can have a significant effect upon payload capability or mission assurance. An analysis was made of the possible strategies which could increase the payload capability of certain critical Saturn V missions. This is based on selective assignment of engines showing high specific impulse as measured in the acceptance tests.(48)
- B. The payload penalty due to decrease of peak g-load in the Saturn V trajectory program was analyzed.(49)
- C. A computer program for the optimization of rocket engine performance based upon combustion kinetics has been completed and a final report is in process. This program facilitates trade-off studies of design features and possible changes in engine performance characteristics. Additions are being made to the program so as to allow the use of heterogeneous (metal additives) propellants for future study purposes.
- D. An addition has been made to the earth-launch trajectory and targeting computer program to provide the ability to compute latitude and longitude of the projection of the trajectory, and the Range Safety Impact Points, on a spherical earth. A further addition to the program is the incorporation of subroutines which will allow the use of solid rockets for main propulsion in this program.
- E. A study was begun of the performance of Saturn IB's using control weights and suborbital ignition of the SPS, with emphasis on polar orbits. A payload gain of approximately 4600 lbs., as compared with a standard two-stage Saturn IB, in a 100 NM polar orbit is indicated. Calculations will be continued to include other orbit altitudes and inclinations.

(48) Statistical Variation in the Performance of Rocket Engine and a Possible Method of increasing Performance of the Saturn V Vehicle (U) TM-65-2011-1, M. W. Cardullo, J. L. Current, February 3, 1965, (CONFIDENTIAL)

(49) Payload Penalty for Decrease in Peak G-Load of Saturn V Vehicle, Memorandum for File, J. J. Schoch, January 19, 1965

- F. Lifetimes of several Apollo spacecraft configurations corresponding to Saturn IB missions were calculated for circular orbits in the altitude range of 70-200 NM⁽⁵⁰⁾. The results are presented in a manner which allows generalization to arbitrary values of weight to drag ratio.
- G. The major considerations governing the use of 100% oxygen atmosphere in the Gemini and Apollo programs were reviewed and the advantages of this choice were outlined.⁽⁵¹⁾
- H. The section dealing with Biomedical Test Requirements of the Apollo Test Requirements Document was reviewed. The resulting report⁽⁵²⁾ formed the basis of discussions with MM and proposed revisions of the Biomedical Section.⁽⁵³⁾

(50) Computation of Earth Orbital Lifetimes for Saturn IB Missions, Memorandum for File, J. J. Schoch, February 19, 1965.

(51) Use of Pure Oxygen in Spacecraft, Memorandum for File, P. R. Knaff, February 8, 1965.

(52) Apollo Test Requirements Document - Critique of Section 5: Biomedical Test Requirements, Memorandum for File, P. R. Knaff, March 4, 1965

(53) Section 5: Biomedical Test Requirements, Apollo Test Requirements Document, Letter to John Disher (MSF) from P. R. Knaff, March 8, 1965

ENGINEERING SUPPORT

COMPUTING FACILITY

Ten RCA supplied multiple access terminals are currently installed and operational. It is expected that two of these terminals will shortly be located in Federal Office Building 10-B where they will provide service to both NASA and Bellcomm personnel located in that building.

The following is a list of major study areas for which programs were written and completed during this quarter.

- (1) Patched Conic Trajectories
- (2) Nardseick Integration
- (3) Apollo Reliability Simulation
- (4) Interface Documentation Analysis
- (5) Apollo Modulation Technique Study
- (6) Saturn V Drag and Heating Calculations
- (7) Omni-Directional Landing System Study
- (8) Interpretation of Ranger Data
- (9) Reference Trajectory Generator
- (10) Reference Trajectory Output Processor
- (11) Applications Programmer Status Reports
- (12) Plot BARS Processor Output
- (13) Landing Statistics
- (14) Plot BARS Simulator Output
- (15) Lunar Orbit Perturbations
- (16) Proton and Electron Flux Calculation
- (17) System Library Maintenance
- (18) BUSCH Subroutine

The applications programming staff members are presently assisting various Bellcomm groups in areas such as the following:

- (1) Space Design Study
- (2) Landing Dynamics
- (3) PERT Capability for Headquarters Master Summary Network
- (4) SCS Control Simulation
- (5) Targeting and Trajectory Program
- (6) Lunar Reconnaissance Trajectory Study
- (7) Guidance and Navigation System Performance Evaluation
- (8) General Purpose Data Storage and Retrieval System
- (9) Analytical Processor for BARS
- (10) Surveyor Area Coverage Study
- (11) Apollo Communications System Capability
- (12) Trajectory Generator

ADMINISTRATIVE

PERSONNEL

As of March 31, 1965, the Bellcomm staff included 199 members in technical occupations and 112 administrative employees.

Contract and Financial

In January the company's books of account were closed for calendar year 1964. The accounting firm of Lybrand, Ross Brothers & Montgomery audited and approved statements of financial results for the year.

BELLCOMM REPORTS AND MEMORANDA

(Listed in Report Date Order)

This index includes technical reports and memoranda issued during this period covering particular technical studies.

The memoranda were intended for internal use. They represent the opinion of the authors at that time. Thus, they do not necessarily represent the considered judgment of Bellcomm which is reflected in the published Bellcomm Technical Reports.

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Project Apollo- Further Studies of Aircraft Deploy- ment to Provide Coverage During the Injection Phase (Memo for File - Special Task 15)</u>	R. C. Peterson T. M. Trecker (Bell Telephone Laboratories, Inc.)	(Unclassified)	December 10, 1964
<u>Effects of Atmospheric Re- fraction on Cov- erage Provided by MSFN Earth Based Communications and Tracking Stations (TM 64-2021-1) (Special Task 15)</u>	H. Pinckernell	(Unclassified)	December 31, 1964
<u>A Proposed Set of Coordinate Systems for Project Apollo (Memo for File - Special Task 9)</u>	J. O. Cappellari J. S. Dudek	(Unclassified)	January 13, 1965
<u>Summary Report on Task 14 - Opera- tional Planning (Memo for File - Special Task 14)</u>	R. W. Sears	(Unclassified)	January 15, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Project Apollo -</u> <u>Additional Results</u> <u>Concerning Aircraft</u> <u>Deployment to Pro-</u> <u>vide Coverage Dur-</u> <u>ing the Injection</u> <u>Phase (MF 5-4332-4)</u> <u>(Special Task 15)</u>	R. C. Peterson (Bell Telephone Laboratories, Inc.)	(Unclassified)	January 15, 1965
<u>Monthly Progress</u> <u>Report for De-</u> <u>cember, 1964</u> <u>(Letter - Special</u> <u>Task 19)</u>	P. L. Havenstein	(Unclassified)	January 15, 1965
<u>Payload Penalty</u> <u>for Decrease in</u> <u>Peak G-Load of</u> <u>Saturn V Vehicle</u> <u>(Memo for File -</u> <u>General Mission</u> <u>Task 3)</u>	J. J. Schoch	(Unclassified)	January 19, 1965
<u>Impact Response</u> <u>Characteristics</u> <u>and Associated</u> <u>Impact Attenuation</u> <u>Techniques for</u> <u>Lunar and Planetary</u> <u>Landing Vehicles</u> <u>(TM-65-1012-1)</u> <u>(Special Task 18)</u>	R. K. McFarland	(Unclassified)	January 21, 1965
<u>Monitoring Pro-</u> <u>cedures and</u> <u>Landing Radar Re-</u> <u>quirements During</u> <u>Powered Descent</u> <u>Phase of the Lunar</u> <u>Excursion Module</u> <u>/U/ (TR-65-209-1)</u> <u>(Special Task 9)</u>	W. G. Heffron	CONFIDENTIAL	January 22, 1965
<u>Lunar Orbiter</u> <u>Mission, Plan-</u> <u>ning /U/ (TR-</u> <u>65-211-1)</u> <u>(Special Task 11)</u>	D. D. Lloyd R. F. Fudali	CONFIDENTIAL	January 25, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Atmospheric Correlation Effects in Range Rate Tracking (MF5-4332-5)</u> (Special Task 14)	G. H. Myers (Bell Telephone Laboratories, Inc.)	(Unclassified)	January 28, 1965
<u>Interim Report for AES Flight Mission Assignment Plan: Part I-Summary /U/ (TM-65-1011-7)</u> (Special Task 18)	T. L. Powers	CONFIDENTIAL	January 29, 1965
<u>Interim Report for AES Flight Mission Assignment Plan: Part II-Propulsion and Trajectory Capabilities (TM-65-1011-1)</u> (Special Task 18)	P. W. Conrad R. Y. Pei	(Unclassified)	January 29, 1965
<u>Interim Report for AES Flight Mission Assignment Plan: Part III-Extended CSM Spacecraft /U/ (TM 65-1011-2)</u> (Special Task 18)	K. E. Martersteck	CONFIDENTIAL	January 29, 1965
<u>Interim Report for AES Flight Mission Assignment Plan: Part IV-LEM Objectives /U/ (TM-65-1011-3)</u> (Special Task 18)	J. E. Waldo	CONFIDENTIAL	January 29, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
Interim Report for AES Flight Mission Assign- ment Plan: Part V - Lunar Mission Objectives and Rationale (TM-65- 1011-4) (Special Task 18)	N. W. Hinnners	(Unclassified)	January 29, 1965
Interim Report for AES Flight Mission Assign- ment Plan: Part VI-Earth Orbital Mission Objectives and Rationale (TM- 65-1011-5) (Special Task 18)	W. B. Thompson	(Unclassified)	January 29, 1965
Interim Report for AES Flight Mission Assignment Plan: Part VII - Sched- uling Constraints and Alternative Schedules /U/ (TM-65-1011-6) (Special Task 18)	P. Gunther	CONFIDENTIAL	January 29, 1965
Interim Report for AES Flight Mission Assign- ment Plan: Part VIII - Launch Fa- cilities and Equip- ment /U/ (TM-65- 1033-1) (Special Task 18)	V. Muller H. E. Stephens	CONFIDENTIAL	January 29, 1965
Bellcomm, Inc. Quarterly Progress Report (October, November, De- cember 1964) (65-101-1)		(Unclassified)	January 29, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Minutes of the Second Apollo Interface Co-ordinate Systems Meeting (Memo for File - Special Task 9)</u>	J. S. Dudek J. O. Cappellari R. L. Wagner	(Unclassified)	February 1, 1965
<u>Saturn IB Test Mission for LEM Alone on SA-206 /U/ (Memo for File - Special Task 17)</u>	D. R. Valley	CONFIDENTIAL	February 1, 1965
<u>Saturn IB/Apollo Payload Capability /U/ (Memo for File - General Mission Task 3)</u>	H. S. London	CONFIDENTIAL	February 2, 1965
<u>A Review of the Readability Potential of the Mission Control Center TV Displays (MF5-4332-7) (Special Task 19)</u>	R. O. Wise (Bell Telephone Laboratories, Inc)	(Unclassified)	February 3, 1965
<u>Draft - Configuration Management of Computer Programming for Apollo (Proposed Text of an MSF Directive - Special Task 22)</u>		(Unclassified)	February 3, 1965
<u>Draft - Report Management of Computer Programming for Apollo (Proposed Text of an MSF Directive - Special Task 22)</u>		(Unclassified)	February 3, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
Draft - Test Management of Computer Program- ming for Apollo (Proposed Text of an MSF Directive - Special Task 22)		(Unclassified)	February 3, 1965
Statistical Variation in Performance of Rocket Engines and a Possible Method of Increasing Per- formance of the Saturn V Vehicle /U/ (TM-65-2011-1) (General Mission Task 3)	M. W. Cardullo J. L. Current	CONFIDENTIAL	February 3, 1965
Unified S-Band Communications Margins Calcu- lations for One- Way Links (TM-65-2021-1) (Special Task 15)	J. D. Hill J. T. Raleigh R. L. Selden	(Unclassified)	February 4, 1965
Comments on "Apollo Program Operations Plan" (Memo for File - Special Task 14)	P. L. Havenstein	(Unclassified)	February 5, 1965
Monthly Progress Report for January, 1965, (Letter - Special Task 19)	P. L. Havenstein	(Unclassified)	February 5, 1965
Use of Pure Oxygen in Spacecraft (Memo for File - General Mission Task 2)	P. R. Knaff	(Unclassified)	February 8, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Lunar Orbit Rendezvous Ref- erence Trajectory Data Package Sensitivity Matrices for Apollo Error Analysis /U/ (STL, 8408-6084- RC000) (Special Task 9)</u>	Space Technology Laboratories	CONFIDENTIAL	February 15, 1965
<u>Lunar Surface Models (Memo for File - Special Task 11)</u>	R. F. Fudali	(Unclassified)	February 15, 1965
<u>The Effect of Rocket Exhaust Gas Impingement on Various Sur- faces (Memo for File - Special Task 11)</u>	N. W. Hinnens	(Unclassified)	February 15, 1965
<u>Interim Report on Lunar Landing Dynamics Specific Engineering Studies (MM-65-2) (Special Task 20)</u>	Bendix Products	(Unclassified)	February 17, 1965
<u>Draft - Project Apollo Coordinate System Standards (The Proposed Text of an MSF Directive - Special Task 9)</u>	R. L. Wagner J. O. Cappellari J. S. Dudek	(Unclassified)	February 19, 1965
<u>Apollo Flight Mission Assign- ments /U/ NPC- C500-11/SE 010-000-1</u>	NASA/MSF	CONFIDENTIAL	February 19, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Computation of Earth Orbital Lifetimes for Saturn IB Missions</u> /U/ (Memo for File - General Mission #3)	J. J. Schoch	CONFIDENTIAL	February 19, 1965
<u>The Micrometeroid Environment of Project Apollo</u> (TR-65-211-2) (Special Task 11)	J. S. Dohnanyi	(Unclassified)	February 25, 1965
<u>Summary of Work Performed Under Belcomm/NASA Task 11 (TR-65- 211-3) (Special Task 11)</u>	B. T. Howard D. B. James G. T. Orrok	(Unclassified)	February 26, 1965
<u>Mission Control Center (MCC) Display Readability Experiments</u> (Memo for File - Special Task 19)	S. J. Schoen	(Unclassified)	February 27, 1965
<u>Sensitivity Matrix Data for LEM Ascent to 50,000 Foot Orbit</u> /U/ (Memo for File - Special Task 9)	I. Bogner	CONFIDENTIAL	March 3, 1965
<u>Review of Pro- curement Plan for Programming Services, MSC Flight Crew Sup- port Division Simulator Complex</u> (Memo for File - Special Task 22)	I. D. Nehama	(Unclassified)	March 3, 1965
<u>Saturn V/Apollo Hold and Recycle Capability (Memo for File - Special Task 24)</u>	C. Bidgood	(Unclassified)	March 4, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Apollo Test Re-</u> <u>quirements</u> <u>Document -</u> <u>Critique of Sec-</u> <u>tion 5: Biomed-</u> <u>ical Test Require-</u> <u>ments (Memo for</u> <u>File - General</u> <u>Mission Task 2)</u>	P. R. Knaff	(Unclassified)	March 4, 1965
<u>Section 5: Bio-</u> <u>medical Test</u> <u>Requirements,</u> <u>Apollo Test</u> <u>Requirements</u> <u>Document (Pro-</u> <u>posed Revision of</u> <u>Section 5 attached)</u> <u>(Letter - General</u> <u>Mission Task 2)</u>	P. R. Knaff	(Unclassified)	March 8, 1965
<u>Communication</u> <u>Reliability for</u> <u>the Apollo Manned</u> <u>Space Flight Net-</u> <u>work (MSFN) Based</u> <u>on Past NASA Net-</u> <u>work Performance</u> <u>(TM-65-2021-2)</u> <u>(Special Task 15)</u>	G. H. Speake	(Unclassified)	March 9, 1965
<u>Procedure for</u> <u>Estimating the</u> <u>Undetected Error</u> <u>Rate for the RCA</u> <u>Data Transmission</u> <u>System (TM-65-</u> <u>1031-1) (Special</u> <u>Task 21)</u>	J. S. Engel	(Unclassified)	March 9, 1965
<u>Monthly Progress</u> <u>Report for</u> <u>February 1965</u> <u>(Letter - Special</u> <u>Task 19)</u>	P. L. Havenstein	(Unclassified)	March 10, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Interim Report on Lunar Landing Systems Engineering Study (TR-65-220-1) (Special Task 20)</u>	D. Macchia J. Nutant	(Unclassified)	March 10, 1965
<u>Unified S-Band Communications Margins During The Launch Phase of a Saturn V Apollo Mission (Memo for File - Special Task 15)</u>	J. D. Hill R. L. Selden	(Unclassified)	March 16, 1965
<u>Minutes of the Third Apollo Interface Coordinate System Standardization Meeting, Houston, Texas, March 4, 1965 (Memo for File - Special Task 9)</u>	J. O. Capellari J. S. Dudek R. L. Wagner	(Unclassified)	March 17, 1965
<u>Ranger VII Photo Analysis - Preliminary Measurements of Apollo Landing Hazards (TM-65-1012-2) (Special Task 11)</u>	C. J. Byrne	(Unclassified)	March 17, 1965
<u>Apollo Saturn V Unified S-Band Communications and Tracking Coverage From Lift-off through Insertion (Memo for File - Special Task 15)</u>	J. P. Maloy H. Pinckernell	(Unclassified)	March 19, 1965
<u>Laboratory Test Methods for Determining Readability of TV Displays (MF5-4332-22) (Special Task 19)</u>	R. O. Wise (Bell Telephone Laboratories, Inc)	(Unclassified)	March 22, 1965

<u>TITLE</u>	<u>AUTHORS</u>	<u>SECURITY CLASS</u>	<u>DATE</u>
<u>Review of Apollo Communication System February 9, 1965 (Memo for File - Special Task 15)</u>	J. J. Hibbert	(Unclassified)	March 23, 1965
<u>Summary of Requirements for Instrumentation Aircraft During the Injection Phase of the Apollo Lunar Landing Mission (Memo for File - Special Task 15)</u>	J. J. Hibbert	(Unclassified)	March 30, 1965
<u>Lunar Landing Site Accessibility for July, 1969 (TR-65-209-3) (Special Task 9)</u>	V. S. Mummert	(Unclassified)	March 31, 1965
<u>Status and Schedule Monitoring of Apollo Software (TR-65-222-1) (Special Task 22)</u>	M. W. Keese, et al	(Unclassified)	March 31, 1965
<u>Draft - Guidelines for the Preparation of Technical Work Statements in Computer Programming in Apollo (Proposed Text of an MSF Directive - Special Task 22)</u>		(Unclassified)	April 7, 1965

GENERAL NOTES

- (1) Following is a list of definitions for the codes used in the various report numbers:

TR - Bellcomm Technical Report
TM - Bellcomm Technical Memorandum
MM - Bell Telephone Laboratories Technical Memorandum
MF - Bell Telephone Laboratories Memorandum for File
STL - Space Technology Laboratories Report
MM - Bendix Report

- (2) General Mission Tasks:

Task 1 - Mission Planning and Mission Assurance
Task 2 - Mission Operations, Including Human Factors and Communications
Task 3 - Vehicle and Spacecraft Systems
Task 4 - Launch Operations and Checkout
Task 5 - Guidance and Navigation

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